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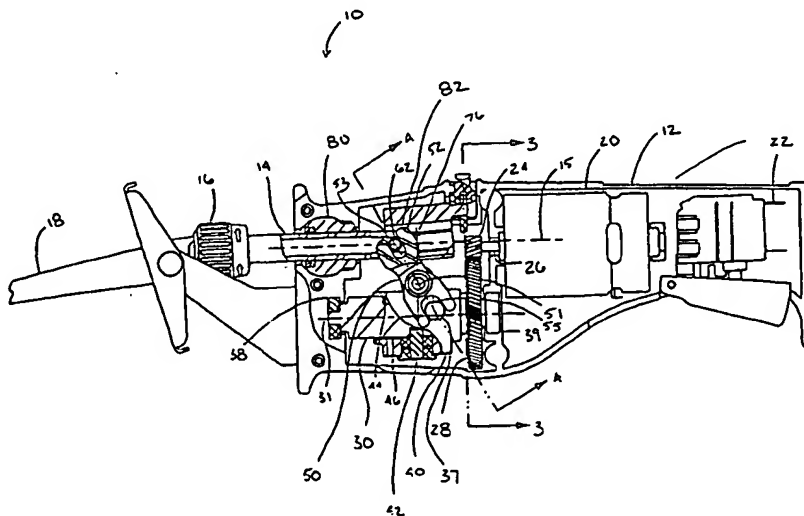
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(54) Title: RECIPROCATING SAW



(57) Abstract

A reciprocating saw (10) including a housing (12), a spindle (14) mounted for reciprocation relative to the housing and having a front end adapted to support a saw blade (18), the spindle being movable through a cutting stroke and a return stroke, a motor (20) for moving the spindle in a reciprocating fashion, and a reciprocating member (40, 50) interconnecting the motor with the spindle. The motor and the spindle define a drive force path from the motor to the spindle and passing through drive force bearing components of the reciprocating saw, and wherein at least part of the reciprocating member is in the drive force path. The reciprocating member is configured to counterbalance the spindle. A pivot body (50) interconnects the spindle with the motor. A shock absorber (66') is operatively positioned between the motor and the front end of the spindle, and is at least partially mounted within the spindle.

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RECIPROCATING SAW

FIELD OF THE INVENTION

5 The invention relates to reciprocating saws, and more particularly to the drive mechanisms of reciprocating saws.

BACKGROUND OF THE INVENTION

10 Reciprocating saws are used to cut a variety of objects, such as metal pipes, wood and drywall. Such saws typically include a housing and a spindle mounted in the housing for reciprocating motion along an axis that is parallel to the longitudinal extent of the spindle. An electric motor provides power to the
15 spindle through a mechanical reciprocating device that converts the rotary motion of a motor shaft to reciprocating motion of the spindle. Such mechanical reciprocating devices can, for example, include an eccentric drive, as disclosed in U.S. Patent No.
20 5,079,844, or wobble plate drive, as disclosed in U.S. Patent Nos. 5,025,562 and 5,050,307.

In addition to various types of drive mechanisms, there are also various types of reciprocating motion. For example, the simplest type is straight linear
25 motion, in which the spindle and blade are translated along a linear path parallel to the spindle and returned along the same path. Alternatively, rocking motion is motion in which the spindle and blade are translated and returned along a path oblique to the
30 spindle axis. Such motion may be straight or curved, and may help to drive the saw blade into the workpiece on the cutting stroke and retract the blade on the return stroke. As another alternative, orbital motion is motion in which the spindle and saw blade are
35 translated along a cutting path and returned along a different path. Typically, the paths form a loop-type movement that forces the saw blade into the workpiece on the cutting stroke and then lifts the saw blade off the workpiece on the return stroke. All of these types

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of movement involve some reciprocation of the saw blade and are therefore considered to be a form of reciprocating motion.

5 The reciprocating motion of the spindle, and other components attached to the spindle such as the saw blade and drive components, causes vibration of the saw. Such vibration makes relative positioning of the saw to the work piece difficult, and can be significant in the case of hand held saws. Therefore, it is known
10 to use a counterbalance that provides an inertial force opposed to the primary reciprocating inertial force. For example, in U.S. Patent No. 5,025,562 issued June 25, 1991 to Palm, a reciprocating saw is disclosed including a counterbalanced reciprocating drive having
15 a jack shaft on which primary and secondary wobble plates are mounted. The primary wobble plate drives the spindle, and the secondary wobble plate drives a mass in a direction opposed to the spindle movement.

20 SUMMARY OF THE INVENTION

Incorporation of a counterbalance into prior art mechanical reciprocating devices, such as eccentric drives and wobble plate drives, can be complex and expensive. Further, the introduction of additional
25 mechanisms into the devices can create another potential point of failure. Accordingly, it is an object of the present invention to design a saw that provides an improved drive mechanism without necessarily adding weight, cost, or complexity. It is
30 a related object of the present invention to provide a reciprocating saw drive mechanism that may be inherently counterbalanced, i.e., the counterbalance is integral to the drive mechanism itself, thus not requiring additional moving parts. It is a further
35 object of the present invention to provide a drive mechanism that incorporates a shock absorbing feature without adding significant weight, cost, or expense.

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In accordance with these objectives, the invention provides a reciprocating saw comprising a housing, a spindle mounted for reciprocation relative to the housing, a motor for moving the spindle in a reciprocating fashion, and a reciprocating member interconnecting the motor with the spindle. The reciprocating member is adapted to move in a direction that is at least partially opposed to the direction of the spindle movement, and the motor and the spindle define a drive force path from the motor to the spindle, and at least part of the reciprocating member is in the drive force path. The reciprocating member may thereby be configured to counterbalance movement of the spindle. For example, the reciprocating member may have substantially the same mass as the spindle.

In one embodiment, the reciprocating member defines an axis and the spindle defines an axis, and the reciprocating member axis is offset from the spindle axis. The reciprocating member axis may be substantially parallel to the spindle axis. The reciprocating saw may further comprise a drive shaft that is driven by the motor wherein the reciprocating member is driven by the drive shaft. For example, the reciprocating member may comprise a barrel cam.

In one aspect, the saw can further include an actuating member in the form of a pivot body having a first end interconnected with the spindle and a second end driven by the motor. The pivot body can be mounted at a pivot point between the first and second ends. The pivot body may be movable perpendicular to pivot axis to thereby vary the extent to which the spindle is driven.

In yet another aspect, the saw includes a shock absorber mounted on the spindle and operatively positioned between the motor and the front end to at least partially absorb impact to the front end. The shock absorber may interconnected between the front end

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and an actuating member, and may be at least partially mounted within the spindle. Preferably, the shock absorber comprises an elastomeric cushion.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a reciprocating saw according to the present invention, shown in partial cross section.

10 Fig. 2 is a perspective view of the reciprocating saw, exploded to show individual components.

Fig. 3 is a cross-sectional view along line 3-3 of Fig. 1.

Fig. 4 is a cross-sectional view along line 4-4 of Fig. 1.

15 Fig. 5 is a perspective view of a portion of another embodiment of the reciprocating drive assembly.

Fig. 6 is a side view, in cross section, of the reciprocating drive assembly portion of Fig. 5.

20 Before one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of the construction and the arrangements of processes set forth in the following description or illustrated in the drawings. The invention is capable
25 of other embodiments and of being practiced or being carried out in various ways. Also, it is understood that the phraseology and terminology used herein is for the purpose of describing the illustrated embodiment and should not be regarded as limiting the scope of the
30 invention.

DETAILED DESCRIPTION

Referring to the drawings, Fig. 1 shows a reciprocating saw 10 according to the present
35 invention. Some components of the reciprocating saw 10 may be similar or identical to components shown in U.S.

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patent application Serial No. 08/699,448, herein incorporated by reference.

5 The reciprocating saw 10 generally includes a housing 12 that is configured to house the drive components at the front end and to fit an operator's hand at the rear end. The housing is split in two halves (Fig. 2), which are combined when the saw 10 is assembled. At the front end of the reciprocating saw 10 is a saw blade 18 mounted to a spindle 14 that reciprocates within the saw 10. Specifically, the saw blade 18 is mounted within a blade clamp 16 at the front end of the spindle 14. Such a blade clamp is shown and described in pending International Application No. PCT/US97/03633, which claims the benefit of U.S. Provisional Application Serial No. 60/021,470, both of which are herein incorporated by reference.

20 In the configuration shown in Fig. 1, the saw blade 18 is oriented such that the serrations will face downward. Thus, the saw blade 18 is configured for downcutting. In some cases, it may be beneficial to reverse the saw blade 18 such that the teeth of the saw blade 18 face upward, thereby configuring the saw for upcutting. The spindle 14, the spindle drive mechanism, and the spindle clamp 16 may be suitably adapted to saw in both directions. Further, the type of motion of the saw blade 18 and the spindle 14 may be varied to make the motion of the saw blade 18 more suitable to upcutting or downcutting, as described hereinafter in further detail.

25 The spindle 14 reciprocates in a generally forward and rearward direction, and defines a spindle axis 15 through the center of the spindle 14. The saw blade 18 is reciprocated and thereby moved through a cutting stroke in one direction and a return stroke in a substantially opposite direction. A motor 20 powers the mechanism of the reciprocating saw 10 and moves the

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saw blade 18 through the cutting stroke and the return stroke. Power from the motor 20 passes through a number of components before being transferred to the saw blade 18. These components thereby define a drive
5 force path that includes those components, or those portions of components, that carry a drive force from the motor 20 through to the spindle 14 and to the saw blade 18.

The motor 20 is fixedly mounted within the housing
10 12. The motor 20 may be externally powered or, as shown in Fig. 1, may include a plug 22 for a battery (not shown) that provides power to the motor 20. The motor 20 drives a motor pinion 24 through a motor shaft 26. The motor pinion 24 engages and drives a drive
15 gear 28.

The drive gear 28 is coaxially mounted to a drive shaft 30. The drive gear 28 and the drive shaft 30 thereby define a drive axis 31. As shown in Fig. 2, the drive shaft 30 includes a shoulder 32 that is sized
20 to fit the inner diameter of drive gear 28. The drive shaft 30 is reduced in diameter at a first end 34 and a second end 36. The first end 34 and the second end 36 are adapted to fit within a front bearing 38 and a rear bearing 39, respectively, that are fixedly mounted by
25 their outer races inside the housing 12. Such bearings may be, for example, radial cartridge bearings.

As shown in Figs. 1 and 2, a reciprocator body 40 fits over the drive shaft 30. The reciprocator body 40 translates the rotary motion of the drive shaft 30 to
30 reciprocating motion. The reciprocator body 40 interacts with the drive shaft 30 by means of a drive pin 42 within a groove 44 of drive shaft 30. The drive pin 42 is held in a fixed position relative to the reciprocator body 40 by a pin retainer cup 46. The
35 drive pin 42 is freely rotatable relative to the reciprocator body 40 and the pin retainer cup 46.

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Two embodiments of the drive pin configuration are shown in the drawings. In the first embodiment, shown in Figs. 1 and 2, a single drive pin 42 rides within a single groove 44. In the second embodiment, shown in
5 Figs. 5 and 6, a drive pin 42' and a follower pin 43' ride within a groove 44' and a follower groove 45', respectively. The follower pin 43' functions to more precisely locate the reciprocator body 40' relative to the drive shaft 30' and thereby prevent backlash. As
10 shown in Fig. 6, the follower pin 43' preferably has a frustoconical tip, and the follower groove 45' is frustoconical in cross-sectional shape to receive the frustoconical tip. A further difference between the two illustrated embodiments is that in the first
15 embodiment of Figs. 1 and 2, the drive pin 42 rotates on bearings 48 separated by spacer 47. In the second embodiment of Figs. 5 and 6, the drive pin 42' and the follower pin 43' rotate on bushings 49', such as sintered brass bushings, that separate the pins from
20 the pin retainer cup 46'.

As one skilled in the art would recognize, the drive pin 42 will preferably be free to rotate relative to the pin retainer cup 46. Thus, the end of the drive pin 42 that rides within the groove 44 is preferably
25 slightly smaller in size than the groove 44. The drive pin 42 will therefore roll along the sidewalls of the groove 44.

The pin retainer cup 46 may comprise a separate assembly that houses the drive pin 42 and is attached
30 to the reciprocator body 40. Alternatively, the pin retainer cup 46 may, as shown in Fig. 2, comprise a plate that is attached at the end of the pin retainer cup to contain the drive pin 42. Such a plate or the entire pin retainer cup 46 may be affixed to the
35 reciprocator body 40 by means of fasteners in order to permit disassembly and repair.

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Figs. 1 and 2 illustrate that the reciprocator body 40 includes a pair of the reciprocator pins 37 that extend from the side of the reciprocator body 40. As shown in the cross section of Fig. 4, the
5 reciprocator pins 37 are reflected on both sides of the reciprocator body 40. The reciprocator pins 37 are generally cylindrical and have flattened top and bottom sides.

The reciprocator pins 37 of the reciprocator body
10 40 engage a pivot body 50. The pivot body 50 transfers the drive force to the spindle 14, and thus functions as an actuating member of the spindle 14. The pivot body 50 is pivotally mounted within the housing 12, and pivots about pivot axis 51.

15 In the first embodiment shown in Figs. 1 and 2, the pivot body 50 is generally Y-shaped and includes a first end 52 that engages the spindle 14, and a second end 54 that engages the reciprocator body 40. As best shown in Figs. 2 and 4, the second end 54 includes two
20 portions that are offset from the central axis of the reciprocating saw 10 and engage the two reciprocator pins 37 on either side of reciprocator body 40. The pivot body 50 further includes a pair of apertures 56 (Fig. 2) on either side of the pivot body 50, the
25 apertures being configured to receive a pivot pin 58. The ends of pivot pin 58 are mounted within bushings 60 that are mounted within the housing 12.

The first end 52 includes an open slot 53 for engaging the spindle, and the second end 54 includes an
30 open slot 55 on each side to engage the reciprocator pins. As the pivot body 50 pivots, and as the corresponding pins that are engaged within the slots 53, 55 reciprocate, the distance of the corresponding pins to the pivot axis 51 of the pivot body 50 changes.

35 Therefore, an elongated slot is desired in the illustrated embodiment.

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The first end 52 of the pivot body 50 engages spindle 14 by means of a spindle pin 62. The spindle pin 62 is cylindrical and engages the slot 53 in the first end 52. As Fig. 2 more clearly shows, the
5 spindle pin 62 passes through an aperture 64 in the spindle 14, and the spindle pin 62 engages the walls of the aperture 64.

In the second embodiment, shown in Figs. 5 and 6, the arrangement of the interconnection between pivot
10 body 50' and spindle 14' is different. The pivot body 50' is generally X-shaped, having two portions on both the first end 52' and the second end 54'. The first end 52' engages the spindle pin 62' on both sides of the spindle 14'. The first end 52' of the pivot body
15 50' is shown as having closed slots 53', instead of an open slot as shown in the first embodiment. As long as the slots 53' are sufficiently long to engage the spindle pin 62' during the entire travel of the spindle 14', either configuration will function properly.

20 In either embodiment, the spindle pin 62 may be flexibly mounted to the spindle 14, such that a shock absorber is mounted between the spindle pin 62 and spindle 14. Fig. 6 shows, in cross section, such an arrangement in which a shock absorber 66' is made of an
25 elastomeric, shock absorbing material, and is interconnected between the spindle pin 62' and the spindle 14'. Because the spindle pin 62' may then move relative to the spindle 14', it is necessary to configure the spindle 14' to permit such movement. For
30 example, in the configuration shown in Figs. 5 and 6, the spindle pin 62' could extend through a longitudinal slot 74' in the spindle 14', instead of the circular aperture 64 shown in Fig. 2.

As shown in the cross section of the spindle 14' in Fig. 6, the spindle pin 62' may be connected to a
35 pin sleeve 68' that fits in the center of the spindle 14' and has a cylindrical passage for retaining the

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spindle pin 62'. The pin sleeve 68' presses against the shock absorber 66', and is mounted behind front shock portion 70' and in front of rear shock portion 72'. The rear shock portion 72' may be smaller such
5 that the shock absorption is more stiff during the cutting stroke. The shock absorber 66 provides greater shock absorption in the event that, for example, the blade strikes a rigid object or is pinched during the return stroke. This increases the life of the
10 mechanism and may prevent damage to the mechanism, as well as aiding the operator comfort.

The spindle 14 does not, in the preferred embodiment, reciprocate only along a spindle axis 15 that is parallel to the drive axis 31. Instead, for
15 more effective cutting, the saw blade 18 can be moved with rocker motion as described in U.S. patent application Serial No. 08/699,448. In short, the spindle 14 is reciprocated by moving the spindle pin 62 within a spindle track 82 having an adjustable
20 inclination. The spindle track 82 thus provides an adjustable spindle path.

Referring to Figs. 1 and 2, the angle of the spindle 14 may be selectively varied by adjustment of the position of spindle track 82. The spindle track 82
25 is pivotally mounted to the housing 12 at one end and can therefore be angled up or down. Referring to Fig. 2, a fixed end 84 includes a pair of track pins 86 that pivotally engage the housing 12. At a free end 88 of the spindle track, a pin 90 extends rearward. The pin
30 90 engages a slot 92 in a cam 94. The slot 92 has a shape that varies the vertical position of the pin 90 as the cam 94 rotates. The cam 94 may rotate relative to the housing. The cam 94 may be moved using a tab 96 that protrudes through the top of the housing 12. By
35 adding frictional engagement points, the cam 94 motion can be made such that the user selects one of several positions of the cam 94. Frictional engagement between

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the cam 94 and the housing 12 thus keeps the cam 94 in a selected position.

5 In a preferred embodiment, the position of the spindle track 86 is adjustable such that the free end 88 is either at, above or below a horizontal position (as viewed in Fig. 1). Thus, the "rocker" motion can be tailored to the particular working conditions, such as the type of material and the blade used. Further,
10 as previously mentioned, the reciprocating saw 10 of the present invention may be used for upcutting and downcutting. The motion of the saw blade 18 may be selected for optimal cutting in both upcutting and downcutting conditions.

15 Referring to Figs. 1 and 2, the spindle 14 is mounted at the forward end of the reciprocating saw 10 by a spindle bushing 80. The spindle bushing 80 has a cylindrical inner surface to engage the outer surface of the spindle 14, and a spherical outer surface so as
20 to be pivotally mounted within the housing 12. In this way, the angle of the spindle 14 relative to the housing 12 may be varied. When the reciprocating saw 10 is adjusted so that the saw blade 18 is rocking up or down, the outside of the spindle bushing 80 pivots
25 relative to the housing 12.

As will be appreciated by one skilled in the art, in the illustrated embodiment the reciprocator body 40 both translates force from the drive shaft 30 to the spindle 14, and also reciprocates in a direction
30 largely opposed to the direction of the spindle 14, thereby counterbalancing the reciprocating saw 10. Thus, the reciprocator body 40 is both a driving mechanism and a counterweight at the same time, without additional mechanisms or complexity. It can be seen
35 that a drive force path exists from the motor 20, through motor pinion 24 and drive gear 28, through drive shaft 30, through reciprocator body 40, through

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pivot body 50, through spindle 14, and finally to saw blade 18. The portion of the reciprocator body 40 that is truly essential for operation of the saw 10 is the portion around drive shaft 30, around groove 44, and that contacts the pivot body 50 (i.e, at reciprocator pin 51). Any additional mass of the reciprocator body 40 serves to reinforce the structure and to provide a counterweight. Because the travel of the spindle 14 and the reciprocator body 40 may be determined by the geometry of the mechanism, the reciprocator body 40 may be designed to provide an inertial force that substantially balances the spindle 14 and therefore the reciprocating saw 10.

More particularly, during the cutting stroke, typically when the saw blade 18 is being retracted, the spindle 14 is travelling along a substantially rearward path. Adjustment of the spindle track 82 moves the path of travel of the spindle 14 and saw blade 18 somewhat, but still the travel is still largely rearward. While the spindle 14 is retracting, the reciprocating member 40 is travelling along a path in a forward direction and parallel to the drive axis 31. Thus, a substantial vector component of the direction of travel of the saw blade 18 and the spindle 14 will be opposed to the direction of travel of the reciprocating member 40 during the cutting stroke. If the spindle 14 is adjusted to reciprocate longitudinally along the spindle axis 15, then the travel will be exactly opposed. During the return stroke, the path of travel of the spindle 14 and the reciprocating member will be exactly the same as the extending stroke, but the components are moving in the opposite direction.

An additional benefit of the invention is that the configuration of the drive mechanism of the reciprocating saw 10 permits adjustment of the length of travel of the spindle 14 and thus the saw blade 18.

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This may be accomplished by varying the position of pivot axis 53. More specifically, pivot axis 53 can be varied up or down as indicated by arrows 76 in Fig. 1, in a direction perpendicular to the drive axis 31 and the spindle axis 15, in order to vary the travel of the spindle 14. Different housings 12 could be created with different pivot axis 53 positions, or the pivot axis 53 position could be made selectively adjustable with a housing 12 having the pivot pin 58 and bushings 60 being movable to different positions and fastenable at a selected position.

While the several embodiments of the present invention has been shown and described, alternative embodiments will be apparent to those skilled in the art and are within the intended scope of the present invention. Therefore, the invention is to be limited only by the following claims:

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Claims:

1. A reciprocating saw, comprising:
a housing;
5 a spindle mounted for reciprocation relative to said housing, said spindle having a front end adapted to support a saw blade, said spindle being movable through a cutting stroke and a return stroke;
a motor for moving said spindle in a
10 reciprocating fashion; and
a reciprocating member interconnecting said motor with said spindle, said reciprocating member being adapted to move in a direction that is at least partially opposed to the direction of the spindle
15 movement, wherein said motor and said spindle define a drive force path from said motor to said spindle, and wherein at least part of said reciprocating member is in said drive force path.
- 20 2. The reciprocating saw of Claim 1, wherein said reciprocating member is configured to counterbalance movement of said spindle.
3. The reciprocating saw of Claim 1, wherein
25 said reciprocating member has substantially the same mass as said spindle.
4. The reciprocating saw of Claim 1, wherein
30 said reciprocating member is positioned to provide an inertial force substantially equal in magnitude and opposite in direction to the inertial force of said spindle during the cutting stroke and the return stroke.

35

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5. The reciprocating saw of Claim 1, wherein said reciprocating member defines an axis and said spindle defines an axis, and wherein said reciprocating member axis is offset from said spindle axis.

5

6. The reciprocating saw of Claim 5, wherein said reciprocating member axis is substantially parallel to said spindle axis.

10

7. The reciprocating saw of Claim 1, further comprising a drive shaft that is driven by the motor, and wherein said reciprocating member is driven by said drive shaft.

15

8. The reciprocating saw of Claim 1, wherein said reciprocating member comprises a barrel cam.

20

9. The reciprocating saw of Claim 1, further comprising a pivot body having a first end and a second end and that is pivotally mounted to the housing, said pivot body being interconnected to said spindle at said first end and interconnected to said reciprocating member at said second end.

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10. A reciprocating saw, comprising:
a housing;
a spindle mounted for reciprocation relative
to said housing, said spindle having a front end
5 adapted to support a saw blade, said spindle being
movable through a cutting stroke and a return stroke;
a motor for moving said spindle in a
reciprocating fashion; and
a pivot body having a first end
10 interconnected with said spindle and a second end
driven by said motor, said pivot body being mounted at
a pivot point between said first and second ends.
11. The reciprocating saw of Claim 10, wherein
15 said pivot body is movably mounted to said housing.
12. The reciprocating saw of Claim 10, wherein
said pivot body is pinned to said housing at said pivot
point.
20
13. The reciprocating saw of Claim 10, further
comprising a reciprocating member driven by said motor,
and wherein said pivot body is interconnected to said
reciprocating member at said second end.
25
14. The reciprocating saw of Claim 13, wherein
said reciprocating member includes a pin, and wherein
said pivot body includes a slot for receiving said pin.
15. The reciprocating saw of Claim 10, wherein
30 said spindle includes a spindle pin, and wherein said
pivot body includes a slot for receiving said spindle
pin.

35

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16. The reciprocating saw of Claim 10, wherein said pivot point is movable perpendicular to pivot axis to thereby vary the extent to which said spindle is driven.

5

17. A reciprocating saw, comprising:

a housing;

a spindle mounted for reciprocation relative to said housing and defining a spindle axis, said spindle having a front end adapted to receive a saw blade and being movable through a cutting stroke and a return stroke;

a motor for moving said saw blade in a reciprocating fashion; and

a pivot body that is driven by said motor and pivots about a pivot axis that is offset from said spindle axis, said pivot body being interconnected with said spindle to reciprocate said spindle, and wherein the position of said pivot body is selectively adjustable by moving said pivot body to vary the magnitude of the cutting stroke.

18. The reciprocating saw of Claim 17, wherein the position of said pivot body is selectively adjusted in a direction perpendicular to the spindle axis to vary the offset between the spindle axis and the actuating member axis.

19. The reciprocating saw of Claim 17, wherein said pivot axis is perpendicular to and offset from said spindle axis.

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20. A reciprocating saw comprising:
a housing;
a spindle mounted for reciprocation relative
to said housing, said spindle having a front end
5 adapted to support a saw blade;
a motor for moving said spindle in a
reciprocating fashion; and
a shock absorber mounted on said spindle and
operatively positioned between said motor and said
10 front end to at least partially absorb impact to the
front end.

21. The reciprocating saw of Claim 20, further
comprising an actuating member that is driven by said
15 motor and that is interconnected with said spindle to
reciprocate said spindle, wherein said shock absorber
is interconnected between said front end and said
actuating member.

20 22. The reciprocating saw of claim 20, wherein
said shock absorber is at least partially mounted
within said spindle.

23. The reciprocating saw of claim 20, wherein
25 said shock absorber comprises an elastomeric cushion.

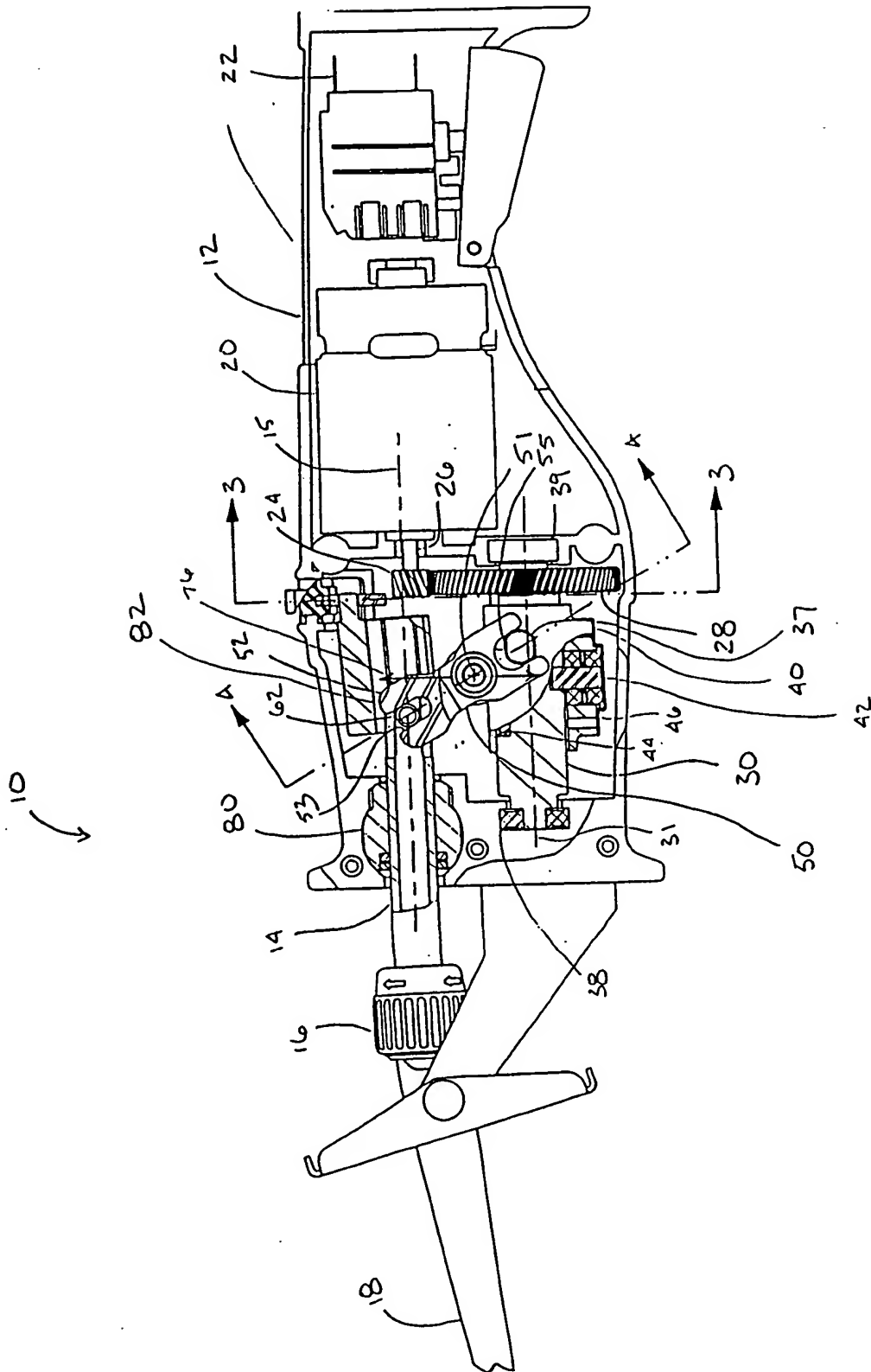


Fig. 1

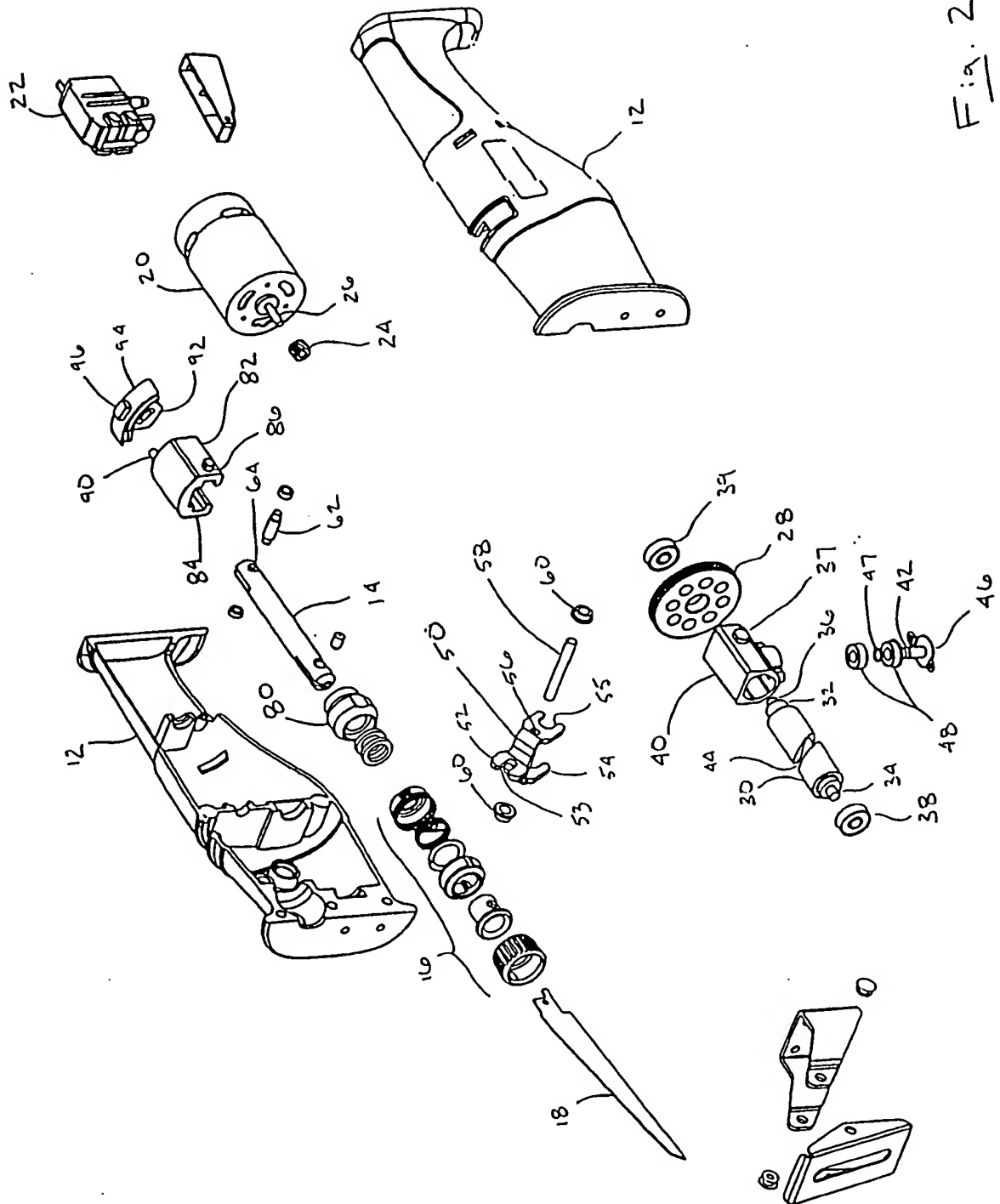
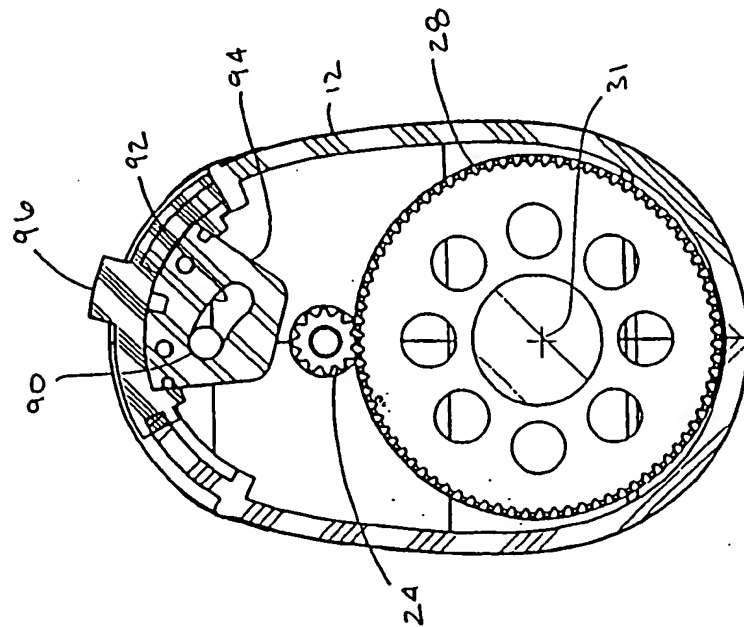
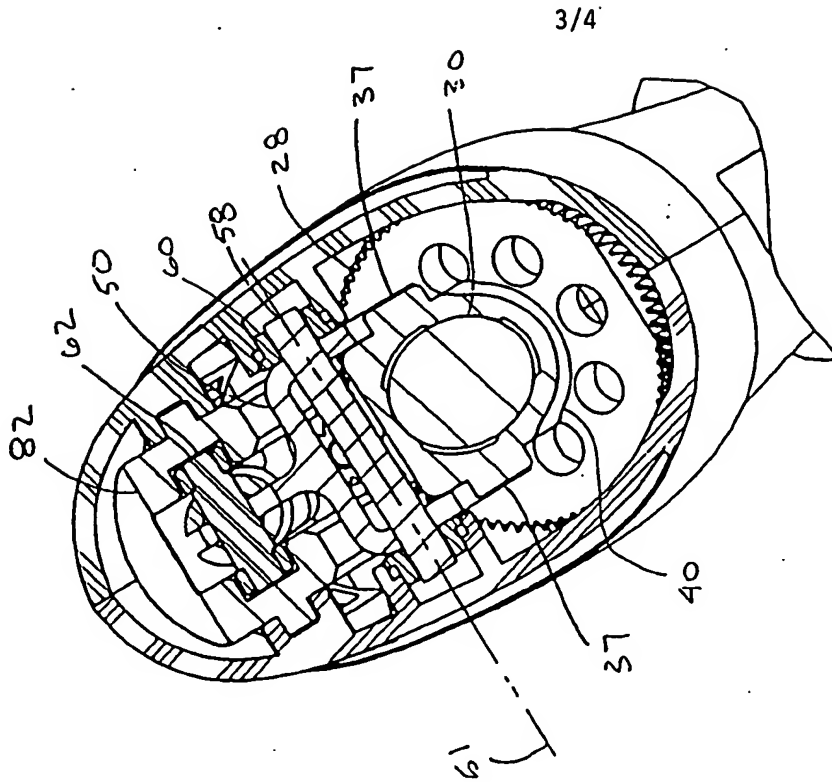
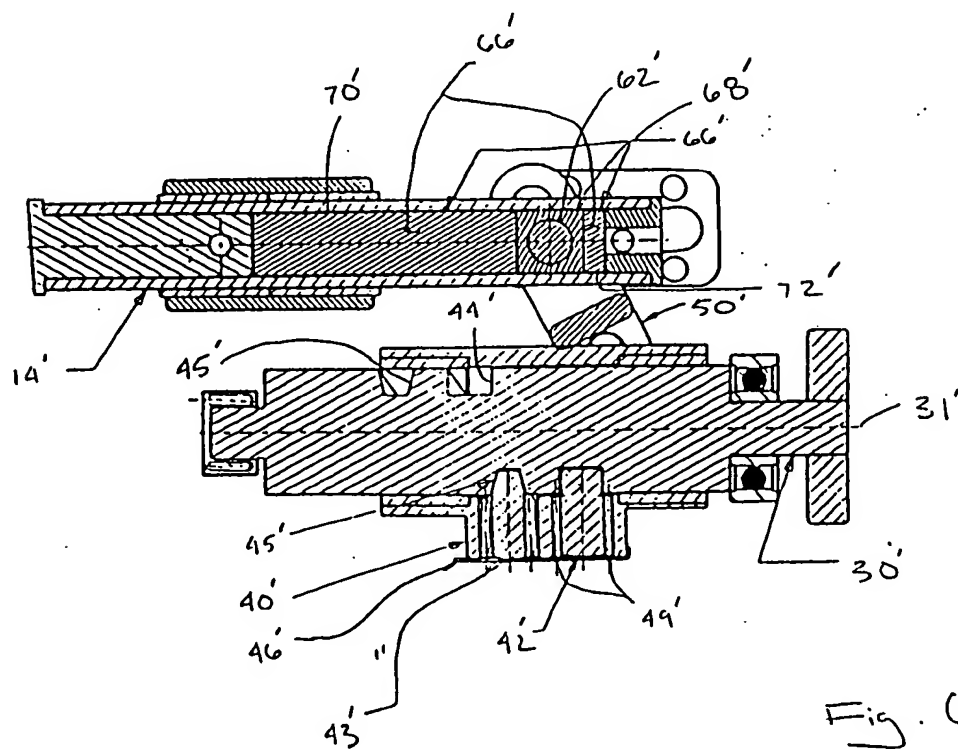
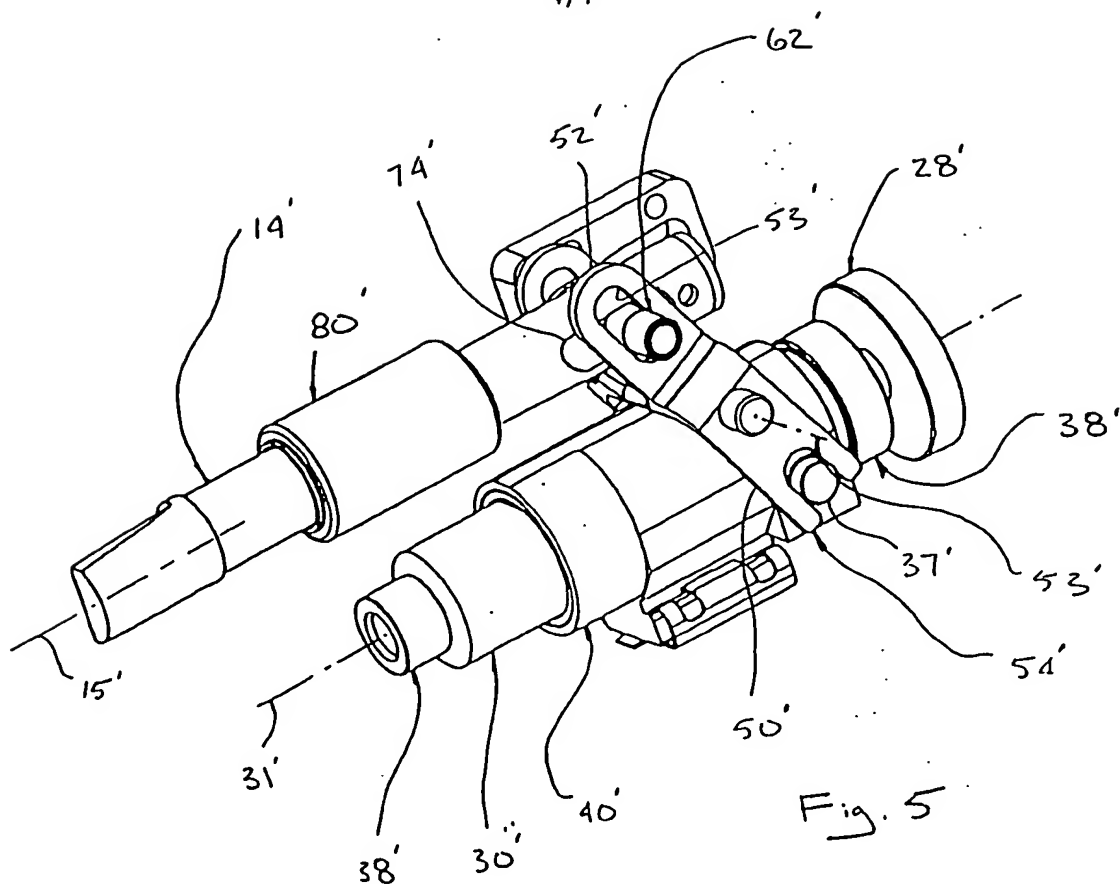


Fig. 2



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INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : B23D 49/16

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 30/393, 392, 394

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|-----------------------|
| X | US 5,450,925 A (SMITH et al) 19 September 1995, Fig. 1, col. 1, line 67 - col. 3, line 55. | 1-23 |
| Y, A | US 5,946,810 A (HOELDERLIN et al) 07 September 1999, Fis. 2-4 | 20-23 |
| Y, A | US 5,782,000 A (BEDNAR) 21 July 1998, Figs. 1-3, col. 3, lines 3-50 | 20-23 |

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

20 December 1999 (20.12.1999)

Date of mailing of the international search report

21 JAN 2000

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